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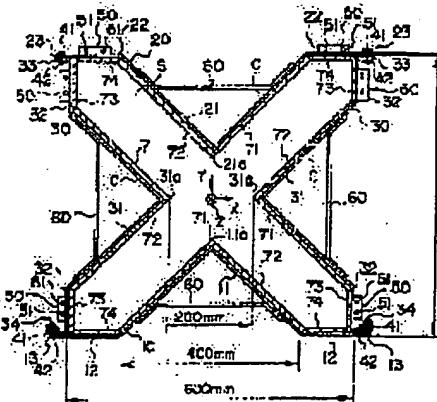
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(54) WAVEGUIDE, RADIO WAVE BLACK BOX AND ELECTROMAGNETIC WAVE TRANSMISSION RECEPTION TEST METHOD

(57) Abstract:

PROBLEM TO BE SOLVED: To provide the small sized radio wave black box, waveguide and the electromagnetic wave reception test method by which a small sized device is tested one by one and in which lots of them are easily installed.

SOLUTION: The black box has a waveguide whose wall face C along its propagation axis Z is made up of conductors and that has a propagation space S through which an electromagnetic wave is propagated from one-end side to the other-end side, and radio wave absorbing bodies 73, 74 mounted onto part of the wall face of the waveguide. The waveguide has the conductor wall face C forming the propagation space around the propagation axis Z at a cross sectional area perpendicular to the propagation axis Z and the radio wave absorbing bodies 73, 74 are arranged at least at positions, remote from the propagation axis in the propagation space formed radially.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to a waveguide, an electric wave black box (an anechoic chamber is included), and an electromagnetic wave transceiver test method, and relates to the electromagnetic wave transceiver test method which used the electric wave black box for the waveguide which has the propagation space which makes an electromagnetic wave spread from an end side to an other end side especially and the electric wave black box which has the same configuration, and the row.

[0002]

[Description of the Prior Art] An anechoic chamber exists a sake [in the case of wanting to measure a precise electrical property in the state the examination of a transmitter, a receiver, etc., and where it is not influenced of a visitor electromagnetic wave etc.]. this kind of anechoic chamber -- general -- a conductor -- what is assembled by the frame by carrying out adhesion junction in a panel, and a conductor -- there are some which are a mesh, for example, surround space in the shape of tentorium [0003] Each of these is in the state in which the operator went into the interior, and does various work, such as measurement. Therefore, it usually has the size which is the grade to which people can move by the interior. If it will become large-sized, it will become a common building and the size not changing.

[0004]

[Problem(s) to be Solved by the Invention] By the way, depending on the object which should be examined, small space may be sufficient. However, although the anechoic chamber mentioned above is suitable for obtaining big electromagnetic-shielding space, it does not have the structure of obtaining small electromagnetic-shielding space. Of course, it is possible to examine a small device by the large-sized anechoic chamber. However, it is not suitable for examining many devices for a short time. That is, in order to avoid interference between devices, there are restrictions that an examination can do only one device at a time, and there is a problem of a low in an experimental throughput.

[0005] The problem of this throughput may be solved to some extent by preparing this kind of anechoic chambers [many]. However, since the anechoic chamber mentioned above is large-sized, it is difficult from both sides of area and cost to install a large number.

[0006] Recently, the spread of mobile communications progresses and the mass production of a small transmitter is getting into stride. The need of examining a transmitter efficiently by the low cost came out with increase of the quantity of production. In the examination of an antenna, the limited examination space must be especially maintained at the conditions near practical use as much as possible, and a high throughput must be maintained. moreover, an antenna tester -- electromagnetism -- you have to offer the shielded space And the size of the tester itself has a desirable thing small as much as possible.

[0007] A size since he wants to examine only the direct wave from an antenna, to the extent that the influence of a multi-pass can be disregarded on the other hand is desirable.

[0008] By the way, it faces [examining small devices, such as a transmitter, and] and it is possible to use a waveguide. However, since a cut off frequency becomes settled from the cross-section configuration in the case of a rectangular waveguide, when it is made small too much, it can be used

about low frequency. For example, in transmitters, such as a cellular phone, it is desirable about the low frequency of about 200MHz that measurement is possible. However, when it is going to realize 200MHz by the rectangular waveguide, one side of a cross section is needed 750mm. Therefore, it is difficult to make it smaller than this.

[0009] Since many anechoic chambers for an examination are needed in order to examine small devices, such as a transmitter, in large quantities as mentioned above, it is desired for the each of to be small as much as possible. For example, a small electric wave black box with which it is settled in the dimension in a field perpendicular to the electromagnetic wave propagation shaft of a rectangular waveguide, and a cut off frequency serves as a low value from the rectangular waveguide is desired.

[0010] The 1st purpose of this invention is to be able to examine one small device at a time, and offer a small electric wave black box with easy moreover installing a large number.

[0011] Moreover, the 2nd purpose of this invention is to offer the suitable waveguide for realization of the above-mentioned electric wave black box.

[0012] Furthermore, the 3rd purpose of this invention is to offer the electromagnetic wave transceiver test method suitable for the examination of small communication equipment.

[0013]

[Means for Solving the Problem] In the electric wave black box which covers an electromagnetic wave according to the 1st mode of this invention in order to attain the 1st purpose of the above The wall surface in alignment with a propagation shaft consists of conductors, and it has the waveguide which has the propagation space which makes an electromagnetic wave spread from an end side to an other end side, and the wave absorber with which a part of wall surface of a waveguide is equipped. a waveguide the conductor which constitutes propagation space in a radial centering on a propagation shaft in a cross section perpendicular to a propagation shaft -- it has a wall surface and the electric wave black box characterized by arranging a wave absorber at least in a position distant from the propagation shaft of the propagation space constituted by the radial is offered

[0014] the conductor to which the wall surface in alignment with a propagation shaft consists of conductors, and constitutes propagation space in a radial centering on a propagation shaft in a cross section perpendicular to a propagation shaft from an end side in the waveguide which has the propagation space which makes an electromagnetic wave spread to an other-end side according to the 2nd mode of this invention in order to attain the 2nd purpose of the above -- the waveguide characterized by to have a wall surface is offered

[0015] In order to attain the 3rd purpose of the above, according to the 3rd mode of this invention, the antenna which carries out electro magnetic radiation to the end side on the propagation shaft of the propagation space is arranged using the electric wave black box shown in the 1st mode of the above, the antenna which receives an electromagnetic wave to an other end side is arranged, and the electromagnetic wave transceiver test method characterized by examining transmission and reception of an electromagnetic wave is offered.

[0016]

[Embodiments of the Invention] The electric wave black box of this invention is constituted using the waveguide which the 2nd above-mentioned mode shows. Then, a waveguide is explained first.

[0017] The wall surface in alignment with a propagation shaft consists of conductors, and a waveguide constitutes the propagation space which makes an electromagnetic wave spread to an other end side from an end side. the conductor from which this invention constitutes propagation space in a radial centering on a propagation shaft in a cross section perpendicular to a propagation shaft in such a waveguide -- it considers as the structure of having a wall surface concrete -- a conductor -- a wall surface is constituted by the cross centering on a propagation shaft in a cross section perpendicular to a propagation shaft in propagation space The cross-section structure of this cross waveguide is typically shown in drawing 1 . In addition, although this invention is explained by making a cross waveguide into an example below, this invention is not limited to this. namely, a conductor -- the thing which make the interior propagation space and to constitute is also possible as structure which faces across the space which meets the diagonal line of right n square shapes (n is even number) centering on a propagation shaft in a cross section perpendicular to a propagation shaft in a wall surface

[0018] The cross section of a cross waveguide has the form which four square portions projected as

shown in drawing 1. The cross-section configuration of a cross is uniform to the z-axis which is a propagation shaft. The electromagnetic wave from the sample offering antenna inserted in the intersection of X is received at the waveguide edge, and a cross waveguide estimates an antenna property. Since it is a symmetrical cross-section configuration, the same conditions can be offered to change of the direction of polarization of an electromagnetic wave. If a wave absorber is installed at the nose of cam of the heights (this portion is called sleeve length Lmax and henceforth) of a waveguide cross section, since reflection within a cross section will become slight, it is expectable to satisfy the conditions of an above-mentioned tester.

[0019] Then, in order to decide the lowest frequency of the absorber used for a tester, it is necessary to analyze a tester as a cross waveguide and to ask for the cut off frequency of the lowest order mode first. The length of a waveguide is assumed to be infinite length in analysis. moreover, a conductor -- a wall is made into a perfect conductor and makes the medium in a pipe homogeneously isotropic by no losing

[0020] The analysis of a waveguide points out asking for the mode which can be spread, and its propagation constant generally. Since the transmission characteristic of a waveguide is decided from the cross-section configuration, it can be said that a cut off frequency is the resonance frequency in the waveguide cross section about each propagating mode. That is, analysis results in solving a two-dimensional eigenvalue problem about a waveguide cross section. Like a circular waveguide or a rectangular waveguide, if it is the form where the cross-section configuration meets an axis of coordinates, it can ask for a propagation constant or a cut off frequency by the separation-of-variables method. However, since analytical technique is inapplicable to the cross-section configuration of the cross waveguide shown in drawing 1, you have to analyze using numerical calculation.

[0021] In order to analyze the property of each propagating mode, since what is necessary is just to ask for the resonance frequency in a waveguide cross section, by this invention, it is calculable using a FDTD (Finite-Difference-Time-Domain) analyzer [finishing / development / as a problem of a cavity resonator already]. Since what is necessary is to deal with only a cross section especially, the two-dimensional FDTD method can be used. in addition, about this technology "KS.Yee:"Numerical solution of initial boundary value problems It is indicated by involving Maxwell's equations in isotropic media"IEEE Trans, Antennas Propagat., vol.AP-14, May 1966, and pp.302-307."

[0022] The FDTD method arranges a strange electromagnetic-field joint regularly to the whole field divided in the shape of a grid, and is the method of carrying out the direct numerical calculation of the difference-ized Maxwell equation. Therefore, the versatility is large, and while the analysis of it is attained also in the circuit of complicated structure, the feature of needing much machine time and storage capacity has it. Moreover, since the FDTD method is an analysis method in a time domain, if the Fourier transform is applied in quest of the response characteristic of an electromagnetic pulse, it can ask for the frequency characteristic by one calculation.

[0023] In the FDTD analysis of a cross waveguide, the parallel monotonous waveguide for transmitting a pulse to the cross-section field of a cross, as shown in drawing 2 is connected. In this case, a cross-section configuration presupposes that it is uniform and is infinite length about the direction of z. Moreover, since it is the electromagnetic field of the waveguide in a cut off frequency, there is no electromagnetic-field change about the direction of z, and it is taken as homogeneity (**/**z=0). energy -- an up-and-down conductor -- it spreads in the **x direction, reflecting between boards It asks for the passage frequency characteristic (scattering-matrix element S21) by carrying out incidence of the pulse from the source side of drawing 2, recording the I/O wave in Point in and Point out, carrying out the Fourier transform of each, and taking a ratio. If it asks for resonance frequency from the graph of the obtained passage frequency characteristic, a cut off frequency is known.

[0024] Next, the analysis technique for asking for a cut off frequency is explained. It is known that the electromagnetic wave which advances in the arbitrary directions and has arbitrary polarization will fill the equation of a helmholtz. Scalar function phi with a as suitable formula as the method of this helmholtz can be introduced, and the method of the Scala helmholtz can express in the form of a formula like the following formula.

[0025]

[Equation 1]
数1

$$\nabla^2 \Psi + k^2 \Psi = 0 \quad \dots (1)$$

[0026] By pillar-shaped system of coordinates, the solution phi of the above-mentioned formula (1) can be divided into the cross-section component phi (x y) and propagation direction component g (z), and can be written as follows.

[0027]
 [Equation 2]
数2

$$\Psi (x, y, z) = \phi (x, y) g (z) \quad \dots (2)$$

[0028] Here, it is a differential operator about a cross section [0029]

[Equation 3]
数3

$$\nabla_t = \nabla - i_z \frac{\partial}{\partial z} \quad \dots (3)$$

[0030] If it carries out, a formula (2) is substituted for a formula (1) and the separation of variables is performed, a formula will be rewritten to the following two differential equations like the above-mentioned method of the Scala helmholtz.

[0031]
[Equation 4]
数4

$$\nabla_t^2 \phi + k_c^2 \phi = 0 \quad \dots (4)$$

[0032]
[Equation 5]
数5

$$\frac{d^2 g}{dz^2} + k_z^2 g = 0 \quad \dots (5)$$

[0033] However, it is $k_c^2 = k^2 - k_z^2$. Moreover, k_c and k_z are the wave numbers of the inside of the cross section decided from the characteristic value of phi and g, and the propagation direction. It is good noting that it changes in proportion to $\exp(-jkzz)$, since g (z) is the general solution of a formula (5). It is solving ** which remains, and a differential equation (4) under the boundary condition decided from a cross-section configuration, and asking for phi.

[0034] electric in the analysis of a waveguide, and electromagnetism -- it is common to take the sense of the-like vector potential in the propagation direction (z shaft orientations) of energy In this case, a propagating mode can be classified into TEz mode and TMz mode about the z-axis.

[0035] The electromagnetic field in a waveguide must satisfy the boundary condition. Boundary condition [in / TMz mode / from Ez=0] since the electric-field tangential component in the tube wall of a waveguide is zero is [0036].

[Equation 6]
数6

$$\phi \mathbf{n} = 0 \quad \dots (6)$$

[0037] It comes out.

[0038] For the electric-field tangential component in the tube wall of a waveguide, since it is zero, the boundary condition in TEz mode is [0039].

[Equation 7]

数 7

$$\frac{\partial \phi_e}{\partial n} = 0 \quad \dots \dots (7)$$

[0040] It is the boundary condition which should be carried out ** satisfactory.

[0041] The cut off frequency in each mode is decided from the value of the wave number kz of the direction of z. The wave number kz is [0042].

[Equation 8]

数 8

$$k_z^2 = k^2 - k_c^2 \quad \dots \dots (8)$$

[0043] It is carrying out ** satisfactory. Here, k and kc are the wave numbers of the direction of a cross section for which can solve fraction [in the medium in a waveguide] omega root (epsilon mu), and a differential equation (4), and it can ask as characteristic value. It is [0044] when it is kz=-alpha+beta now.

[Equation 9]

数 9

$$k_z = \beta = \sqrt{k^2 - k_c^2} \quad (k^2 > k_c^2) \rightarrow g(z) \propto e^{-\beta z} \text{ 伝搬域}$$

$$k_z = j\alpha = j\sqrt{k_c^2 - k^2} \quad (k^2 < k_c^2) \rightarrow g(z) \propto e^{-\alpha z} \text{ 非伝搬域(減衰域)} \dots \dots (9)$$

[0045] It becomes. Therefore, cut-off-frequency omega_c is the frequency at the time of kz=0 [2], i.e., k2=kc, and is [0046].

[Equation 10]

数 10

$$\omega_c = \frac{k_c}{\sqrt{\epsilon \mu}} \quad \dots \dots (10)$$

[0047] It becomes. In addition, epsilon and mu are the dielectric constants and permeability of a medium, respectively.

[0048] Now, kc is characteristic value which solves the differential equation (4) about a cross section suitable boundary condition (6) or under (7), and is obtained. Since the propagation constant beta of a waveguide and cut-off-frequency omega_c can be calculated from the value of kc, it can be said that the propagation property of a tubed waveguide is decided by the cross-section configuration. In the cut off frequency in each mode, since it is set to kz=0, energy will not be transmitted in the direction of z, but will be in the resonance state which repeats a multiple echo within a cross section.

Therefore, it can be said that the cut off frequency to each mode of a waveguide is the resonance frequency about each mode in a waveguide cross section (two-dimensional).

[0049] As shown in drawing 2, if a cross waveguide makes length l of a sleeve zero, a cross section will become a square rectangular waveguide. Then, it carries out based on the propagating mode of a rectangular waveguide, and the lowest order mode of a cross waveguide cross section is considered.

[0050] The characteristic value of a rectangular waveguide can be analytically calculated by using the general solution and the separation-of-variables method for TEz and TMz mode. The solution (4) to can be written as follows about the rectangular waveguide which shows the cross section to drawing 3.

[0051]

[Equation 11]

数1 1

TM²モード

$$\phi_m(x, y) = A \sin\left(\frac{n\pi}{a}x\right) \sin\left(\frac{m\pi}{b}y\right) \quad \dots (11)$$

$$k_z^2 = k^2 - \left(\frac{n\pi}{a}x\right)^2 - \left(\frac{m\pi}{b}y\right)^2$$

[0052]

[Equation 12]

数1 2

TE²モード

$$\phi_m(x, y) = A \cos\left(\frac{n\pi}{a}x\right) \cos\left(\frac{m\pi}{b}y\right) \quad \dots (12)$$

$$k_z^2 = k^2 - \left(\frac{n\pi}{a}x\right)^2 - \left(\frac{m\pi}{b}y\right)^2$$

[0053] since the solution from which n is set to m and 0 does not exist in TM_{mn} mode -- m>=1 and n>=1 -- it is -- therefore -- TM_{mn} mode -- TM_{z11} -- the minimum -- it is a degree -- the form of a formula (11) to a seal, or ** since the solution from which any one of m or the n is set to 0 exists in TE_{zm} mode on the other hand -- TE_{z01} or TE_{z10} -- the minimum -- it becomes a degree

[0054] On the other hand, a cross waveguide is considered to be the form where 4 angles of the rectangular waveguide of a=b were made to project. If the sleeve is lengthened, while electric field satisfy boundary condition, it begins to be distributed from the state of the rectangular waveguide of l= 0 in a sleeve. If it thinks that the cross waveguide was derived from the rectangular waveguide, it can be assumed that the lowest order mode is a part of TE_{zm} mode too. The example of an electromagnetic-field distribution of TE_z and TM_z which were assumed about the cross waveguide is shown in drawing 4. therefore, the minimum of a cross waveguide cross section -- when calculating the following cut off frequency by the two-dimensional FDTD method, what is necessary will be just to analyze about TE_z mode

[0055] When asking for the resonance frequency about a cross waveguide cross section using the FDTD method, as shown in drawing 2, an parallel monotonous waveguide is attached to a cross waveguide cross section, an parallel monotonous waveguide circuit is formed, and it asks for the resonance frequency as a 2 opening cavity resonator. In this case, about the direction of z, a cross-section configuration is uniform and let length be infinite length. moreover, in the cut off frequency in each mode, there is no electromagnetic-field change of the direction of z (**/**z=0) -- it is -- the upper and lower sides in which energy spreads infinitely -- a conductor -- it spreads in the **x direction, reflecting a wooden floor Then, a waveguide cross section is asked for the resonance frequency as a two-dimensional cavity resonator. That is, if the frequency of the electromagnetic field inputted from the source side shown in drawing 2 is swept, only the resonance frequency of a cross waveguide will reach to Point out, without reflecting an electromagnetic wave in a cavity. In two-dimensional FDTD analysis, instead of sweeping, pulse-like electromagnetic field are inputted, the Fourier transform of the observed response characteristic is carried out, and a passage property is searched for.

[0056] Next, the analysis result by the FDTD method mentioned above is described. First, in the case of a rectangular waveguide, as shown in drawing 2, in order to input the electric-field component E_y which constitutes TE_z mode, an parallel monotonous waveguide is attached in the both-sides wall of a rectangular waveguide, and is performed. In addition, both the rectangular waveguide width of face a and height b may be 200mm.

[0057] Here, the cut off frequency of each propagating mode of a rectangular waveguide is analytically given by the following formula.

[0058]

[Equation 13]
數 13

$$f_c = \frac{1}{2\sqrt{\epsilon\mu}} \sqrt{\left(\frac{n}{a}\right)^2 + \left(\frac{m}{b}\right)^2} \quad \dots (13)$$

[0059] Next, the analysis result about a cross waveguide is described.

[0060] Next, from a wave-source (SOURCE) side, the impulse of an electric-field E_y component is inputted and the wave of the electric field $E_y(t)$ in the input point (inch point) and the outputting point (out point) in drawing 2 is searched for by FDTD. The result is shown in drawing 10 from drawing 5, respectively.

[0061] The distribution of Pulse $E_y(t)$ and ($t=200dt$ - $500dt$) which carried out incidence to the cross waveguide by setting time serration width of face to dt is shown in drawing 5. In drawing 5 (a), $t=200dt$ is a time of a pulse reaching X waveguide, and can observe the pulse component which carried out incidence to the pulse component reflected by opening of X waveguide, and X waveguide. Then, the reflected pulse spreads an parallel monotonous waveguide and the outside of a calculation field and the incidence pulse are spread from the inside of X waveguide to the portion of a sleeve (refer to drawing 5 (b) and (c)). Moreover, in drawing 5 (d), a pulse is gradually left in $t>500dt$ from the parallel monotonous waveguide which connected while repeating the multiple echo. Here, the width of face of an parallel monotonous waveguide is the same as the case of the analysis of a rectangular waveguide. On the other hand, since the cross section is quite large compared with a rectangular waveguide, a cross waveguide takes long time by external Q of a cavity becoming high, therefore emitting a total energy. Then, in $l=L_{max}$, it calculates to $t=30000dt$.

[0062] Change of resonance characteristic [of the cross waveguide cross section at the time of changing the length of a sleeve into drawing 6 drawing 7, and drawing 8 from $l=0$ to $L_{max}=282.8mm$] and resonance frequency, i.e., cut off frequency, ** is shown, respectively. Moreover, the case where the output pulse wave observed with Point out in the analysis of X waveguide is set to L_{max} when the length of a sleeve is made into zero is shown in drawing 9 the same [with having been shown in drawing 6] about a rectangular waveguide.

[0063] In addition, in drawing 9, (A) shows a reflected wave and (B) shows a passage wave, respectively. Moreover, in drawing 9 (A) and (B), a horizontal axis is the number of time serration, and a vertical axis shows the strength (arbitrary scale) of electric field E_y . In addition, time serration width of face dt is set to 3.34psec. Moreover, in these graphs, it is the total length over coupling faces of a sleeve ratio [as opposed to l/L_{max} / the length of a sleeve, and] / 1 / the total length over coupling faces of the sleeve of the length 1 of a sleeve in $r/(l/L_{max})$.

[0064] The value of the resonance frequency of drawing 8 is read in the graph of drawing 6 and drawing 7, observing the symmetric property of the graph near resonance frequency. The error accompanying reading is considered to be a **6MHz (frequency data interval) grade at the maximum. In the case of $l=0$, the result that resonance frequency is from 756 to 762MHz is obtained. the minimum of a rectangular waveguide ($l=0$) in which this can be found by the formula (13) -- it turns out that it is well in agreement with the 750MHz of the cut off frequencies as follows If a sleeve becomes long, frequency will become low and, in $l=L_{max}$ (i.e., the cut off frequency of X waveguide), it will be set to 200MHz.

[0065] In the graph of drawing 6 and drawing 7, the curve is [the neighborhood level fell] wavy. This is considered that the influence of the side lobe of the rectangular window used for the discrete Fourier transform has come out. In drawing 9, when the output pulse electric-field wave the case of the length $l=0$ of a sleeve and in L_{max} is compared, by the rectangular waveguide (a) of $l=0$, it turns out that the amplitude of electric field is not easily converged by the cross waveguide (b) of L_{max} to converging early comparatively with time. This is because long time is needed until the total energy in the cavity is emitted in a cross waveguide cross section with bigger external Q. Although the rectangular window was hung in $t=30000dt$, since it was not yet being completed fully by the electric-field amplitude in $l=L_{max}$, the influence of the side lobe of the hung rectangular window comes out. Then, although time was changed and being calculated also about the case of $t=6000dt$ and $t=24000dt$, the graph was eternal about the resonance point, although sharpness was lost to the wave. Therefore, the influence of a rectangular window is convenient to the purpose of the

analysis of this invention.

[0066] Next, the lowest order mode to X waveguide is assumed like drawing 4. then, the minimum - it inputs into the cross waveguide resonance circuit which shows the continuous wave of the 200MHz of the cut off frequencies as follows to drawing 2, and asks for an electric-field distribution. The distribution of the standing wave made in drawing 10 in the cross waveguide in $t=15850dt$ of E_y and E_x is shown. All E (ies) are like-pole nature and the polarity respectively same in two pairs of each sleeves which E_x has in a vertical angle on the other hand, and according to the pair, it is mutually different polarity, and further, both E_y E_x (es) are distributed so that all diagonal sleeve length may turn into the half-wave length. If the synthetic vector of E_y and E_x is searched for in consideration of the sense of the above electric field, the electric-field distribution of the TE mode of the cross waveguide shown in drawing 4 turns out to be a bird clapper easily. Moreover, electric field are concentrating on the intersection of X. especially -- the hidden line of E_x -- from drawing without processing, it turns out that the direction component from which E_x differs is concentrating on the intersection, and this also shows the validity of assumption of drawing 4. Since electric field are distributed over XY both directions the half-wave length every, they are considered to be the mode which should be called TEz11.

[0067] the minimum from the electric-field distribution map shown above -- the following cut off frequency is considered to mainly have been decided by the overall length of a diagonal sleeve the length -- the minimum -- since it is a degree, it must be equivalent to one half of lambdac of a cutoff wave length that is, the minimum -- whenever it sets to L the length of the portion which determines the following cut off frequency, the products of L and a cut off frequency f_c are $f_c L = f_c \lambda$ $c/2 = v_0/2$, and should become fixed in the half of the velocity of light v_0 . For example, since a length of one side of a rectangular cross section is 200mm, the product is set [as opposed to / a 750MHz cut off frequency / the case of the rectangular waveguide of $l=0$] to $v_0/2 = 1.5 \times 10^8$ (m/s). The result which performed calculation same about each **** which carried out the length of a sleeve to $r=1/1$ about the cross waveguide is shown in drawing 11 [4-1]. Since the measurement criteria of the length of a sleeve cannot be decided uniquely in the case of a cross waveguide, as shown in this drawing, L_{short} and L_{long} are used as length of L. since the property as a rectangular waveguide is strong and a cut off frequency is mainly decided by side-attachment-wall pipe distance, when a sleeve is short -- the length of a sleeve, and the minimum -- there is no above-mentioned relation between the following cut off frequencies however -- if a sleeve becomes long -- between $f_c L_{short}$ and $f_c L_{long}$ -- the value of $v_0/2 = 1.5 \times 10^8$ -- entering -- coming -- therefore, the minimum of a cross waveguide -- it turns out that the following cut off frequency was mainly decided by all diagonal sleeve length

[0068] By this invention, since a cut off frequency is decided by the length of the diagonal line of the square inscribed in it when [which was described above] a waveguide is made into a cross, low frequency is [like] realizable from the cut off frequency decided by square length of one side. Therefore, if an electric wave black box is constituted using such a waveguide, since a cut off frequency can be made low, there is an advantage to which the range of the frequency which can be examined spreads. For example, in the case of the cross waveguide settled in one-side the square of 600mm, as shown in drawing 1, as above-mentioned explanation showed, it can consider as a 200MHz cut off frequency.

[0069] Since according to this cross waveguide a cut off frequency can fall as mentioned above, it is small and the transmission line of a wide band can be constituted. especially, this cross waveguide can constitute the transmission line which can carry out until transmission to a low band from low-pass [realizable / with the rectangular space which is occupied physically and to circumscribe]

[0070] What is necessary is just to arrange a wave absorber inside, in order to constitute an electric wave black box by the cross waveguide mentioned above. As a wave absorber, a dielectric, an urethane-foam absorber, etc. which coated a ferrite, ferrite rubber, and carbon are used. What is necessary is just to set up an absorption property so that it may have the cut off frequency of a cross waveguide which should load with it as center frequency. Moreover, although those configurations change also with arrangement positions, a board, the pyramid structure, etc. are mentioned. This wave absorber can be arranged all over the edge of each branch space (building envelope of a sleeve) of a cross waveguide, the ridgeline portion for an intersection, and a wall surface etc.

[0071] Moreover, an electric wave black box should just enlarge the length of each branch space, in order to use it to low frequency more. Of course, it is good also as the size whose square which circumscribes it is the conventional anechoic-chamber grade, and a size which becomes. Even if it is that case, there is an advantage which can treat the electromagnetic wave of low frequency from the conventional anechoic chamber.

[0072]

[Example] Next, the example of this invention is further explained with reference to a drawing.

[0073] One example of the cross waveguide of this invention is shown in drawing 12. The wall surface C in alignment with the propagation shaft Z consists of conductors, and the cross waveguide shown in this drawing constitutes the propagation space S which makes an electromagnetic wave spread to an other end side from an end side. a conductor -- a wall surface C constitutes the propagation space S in a radial centering on the propagation shaft Z in a cross section perpendicular to the propagation shaft Z the case of drawing 12 -- a conductor -- a wall surface C constitutes the propagation space S in a cross centering on the propagation shaft Z in a cross section perpendicular to the propagation shaft Z

[0074] a conductor -- a wall surface C is formed by this example, using a metal plate as a conductor. Specifically, it is constituted combining three kinds of members which bent and fabricated the copper plate of 1-3mm of board thickness. That is, the part I material 10 used for a base side, the part II material 20 which counters it and is used for an upper surface side, and the part III material 30 which they do and is used for right and left, respectively are used.

[0075] These members, 10 and 20, and 30 and 30 face mutually, respectively, and, fundamentally, it has the same gestalt about the field which forms the propagation space S. That is, as shown in drawing 12, a cross section has the V character sections 11, 21, and 31 bent in the shape of V character. In this example, as for the V character each sections 11, 21, and 31, the bending angle is making 90 degrees. Moreover, on both the outsides of the effective area of each V character section 11, 21, and 31, each part material 10, 20, and 30 is in the extended state, and has flat parts 12, 12, 22, 22, 32, and 32, respectively. The flat part 12 and 22 between members which these flat parts counter, i.e., flat parts, and flat parts 32 and 32 are in the assembled state, and are parallel, respectively. Moreover, the adjoining flat parts 12 and 32, and 22 and 32 become perpendicular in the state where it was assembled. The propagation space S is closed by flat parts 12, 12, 22, 22, 32, and 32. furthermore, the V character each sections 11, 21, and 31 -- respectively -- reinforcement -- the member 60 is attached

[0076] reinforcement -- it bends and a member 60 is constituted so that the wall surface of the V character section may be met [plate] in ends this reinforcement -- a member 60 is formed in two or more places in accordance with the propagation shaft orientations of a waveguide in addition, reinforcement -- a member 60 can also be formed over the overall length of a waveguide

[0077] Flat parts 12, 22, and 32 have the connection sections 13, 23, 33, and 34 for connecting each other ahead of a contact portion with the adjoining flat part, respectively. The connection section 13 is bent in the shape of L character so that it may become parallel to the adjoining flat part 32. The nose-of-cam side of the connection section 13 is bent to the adjoining flat part 32 side because it assumes that this part I material 10 constitutes the base side of a cross waveguide. The connection section 34 is bent by the cross-section ditch type to the flat part 32 so that it may be located inside the above-mentioned connection section 13. This connection section 13 and the connection section 34 located in the inside are fixed by the holddown member which consists of a bolt 41 and a nut 42. Moreover, the connection section 23 is formed where a flat part 22 is extended as it was. On the other hand, the connection section 33 is bent right-angled to a flat part 32 so that it may become parallel to the connection section 23. The connection section 23 and the connection section 33 are fixed by the holddown member which consists of a bolt 41 and a nut 42.

[0078] In case it connects with other waveguides, the connection section 50 for fixing each other is formed in the position which serves as an end face of a waveguide, respectively flat parts 22, 22, and 32 and 32, respectively. Two breakthroughs 51 for letting a bolt pass are formed in this connection section 50.

[0079] An example of the size of a cross waveguide is shown in drawing 12. As shown in this drawing, one side has structure dedicated to the square which is 600mm. Moreover, the width of face

of the effective area of the V character sections 11, 21, and 31 is 400mm. Furthermore, it is 200mm between ** 31a of the V character section 31, and ** 31a of the V character section 31 which counters, and between ** 11a of the V character section 11, and ** 21a of the V character section 21 which counters. That is, it has the same size as the cross waveguide typically shown in drawing 1. Therefore, this cross waveguide can expect the property analyzed about X waveguide shown in drawing 1. That is, a cut off frequency can be set to 200MHz.

[0080] Next, the 1st example of the electric wave black box constituted using a cross waveguide is explained with reference to drawing 13.

[0081] The electric wave black box shown in drawing 13 is constituted using the cross waveguide shown in above-mentioned drawing 12. Therefore, the explanation about a cross waveguide is omitted.

[0082] The electric wave black box of this example sticks a ferrite on the inside of the wall surface C of a cross waveguide as a wave absorber, and is a **** thing. Specifically, as shown in drawing 12, it sticks on the portion of the V character sections 11, 21, and 31, sticks on the **** ferrite boards 71 and 72 and a flat part 32, and sticks on the **** ferrite board 73 and flat parts 12 and 22, and there is a **** ferrite board 74. These are boards with a thickness of 3.5mm, for example, are stuck on the wall surface C which corresponds with adhesives, such as an epoxy resin.

[0083] It is absorbed whenever an electromagnetic wave carries out incidence of such a wave absorber to a wall surface C by pasting ***** at a wall surface C. Thereby, the power of the reflected wave in a wall surface C is reduced, and the influence of the reflected wave to the direct wave to propagation shaft orientations is reduced.

[0084] Next, the 2nd example of the electric wave black box of this invention and the 3rd example are explained with reference to drawing 14 and drawing 15. Each of these examples is examples which use a cross waveguide for drawing 12. Therefore, a part of the branch is shown. However, other branches are the same structures.

[0085] The 2nd example shown in drawing 14 is an example by which the wave absorber 80 is arranged in the shape of V character in accordance with the propagation shaft orientations of a cross waveguide inside flat parts 22 and 32. The ferrite is used in this example. In addition, you may be ferrite rubber etc.

[0086] The 3rd example shown in drawing 15 (A) and (B) arranges a wave absorber 90 at intervals of d to the propagation shaft orientations of a cross waveguide at the nose-of-cam side of the branch of a cross waveguide, i.e., the space inside flat parts 22 and 32. The dielectric board with which the wave absorber 90 used in this example coated the wave absorber of a tabular, for example, a ferrite board, and carbon is used. Moreover, this wave absorber 90 has formed the taper 91. Length L of this portion can extend a frequency band by lengthening this. It is desirable to take in this example or more [of the cutoff wave length of a cross waveguide] to 1/4. In addition, the arrangement interval d of a wave absorber 90 is defined experimentally. For example, d can be set to 20-30mm.

[0087] The above example is an example of an electric wave black box. However, these are suitable, when a size is enlarged and it considers as an anechoic chamber. On the other hand, although it is applicable also as an electric wave black box, the example described below is a suitable example when making it into an anechoic chamber especially. Therefore, it explains as an example of an anechoic chamber.

[0088] The 1st example of an anechoic chamber shown in drawing 16 makes large to the grade which can be used as an anechoic chamber size of the cross waveguide shown in drawing 12. For example, you may be about 10 times. Now, as shown in drawing 16, the configuration with a fundamental this example is common in the cross waveguide shown in drawing 12. However, the points used as the rests 11b, 21b, 31b, and 31b which carried out flattening of the portion of ** 11a, 21a, 31a, and 31a in drawing 12 differ. In this example, like the case where it is shown in drawing 14 described above at the edge of a branch, while arranging a wave absorber 110 in the shape of V character, the band-like wave absorber 121 and the pyramid type wave absorber 122 placed on it are arranged to each above-mentioned rests 11b, 21b, 31b, and 31b. As a wave absorber 110 and a band-like wave absorber 121, a ferrite is used, for example. Moreover, as a pyramid type wave absorber 122, a ferrite, an urethane-foam wave absorber, etc. are used, for example. In this example, since the rest was prepared and the wave absorber is prepared on it, a polarization property is improvable.

Moreover, since the pyramid type wave absorber 122 is carried on the band-like wave absorber 121, it contributes to this lowering a low frequency field.

[0089] Next, the 2nd example of an anechoic chamber shown in drawing 17 approaches by the nose-of-cam side, and it is established so that it may keep away by the end face side so that the wall surface C of an anechoic chamber may be constituted in X configuration and the wall surface C which counters may become respectively un-parallel. Moreover, like the case of above-mentioned drawing 16, flattening of the portion of ** is carried out and Rests 11c, 21c, 31c, and 31c are formed. The wave absorber is arranged at the inside of a wall surface C. Thereby, the specular reflection power in a wall surface C is reduced, and there is an effect which makes interference to a direct wave small. In this example, the wave absorber 210 for RFs and the wave absorber 310 for low frequency are used as a wave absorber. All have adopted the pyramid type. Of course, it is not restricted to this. In addition, the wave absorber 310 for low frequency can reduce a low frequency field further by arranging tabular wave absorbers, such as a ferrite, and placing a pyramid type wave absorber on it.

[0090] In this example, the door 400 is formed in a part of wall surface. Thereby, the interior can be frequented easily.

[0091] Since a cut off frequency is determined depending on the length of the diagonal line of the square which circumscribes it in this example as well as the case of the cross waveguide shown in above-mentioned drawing 12, compared with a cut off frequency being determined for the waveguide of the square to circumscribe depending on a length of one side, a low cut off frequency is more realizable. That is, if it is the same cut off frequency, an anechoic chamber with a small feudal area to occupy is realizable.

[0092]

[Effect of the Invention] According to this invention, it can examine one small device at a time, and, moreover, an electric wave black box with easy installing a large number can be realized.

[0093] Moreover, according to this invention, the suitable waveguide for realization of the above-mentioned electric wave black box can be offered.

[0094] Furthermore, according to this invention, the electromagnetic wave transceiver test method which can moreover carry out the base examination of a majority of every one small communication equipment in parallel is realizable.

[0095] In addition, an anechoic chamber with a small area is realizable.

[Translation done.]

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CLAIMS

[Claim(s)]

[Claim 1] the conductor to which the wall surface in alignment with a propagation shaft consists of conductors, and constitutes propagation space from an end side in a radial centering on a propagation shaft in a cross section perpendicular to a propagation shaft in the waveguide which has the propagation space which makes an electromagnetic wave spread to an other end side -- the waveguide characterized by having a wall surface

[Claim 2] a claim 1 -- setting -- a conductor -- the waveguide characterized by a wall surface constituting propagation space in a cross centering on a propagation shaft in a cross section perpendicular to a propagation shaft

[Claim 3] a claim 1 -- setting -- a conductor -- the waveguide characterized by for a wall surface facing across the space which meets the diagonal line of right n square shapes (n is even number) centering on a propagation shaft in a cross section perpendicular to a propagation shaft, and constituting propagation space

[Claim 4] the conductor which is equipped with the following and constitutes propagation space in a radial centering on a propagation shaft in a cross section with a waveguide perpendicular to a propagation shaft -- the electric wave black box which has a wall surface and is characterized by arranging a wave absorber at least in a position distant from the propagation shaft of the propagation space constituted by the radial and which covers an electromagnetic wave The waveguide which has the propagation space which the wall surface in alignment with a propagation shaft consists of [space] conductors, and makes an electromagnetic wave spread from an end side to an other end side. The wave absorber with which a part of wall surface of a waveguide is equipped.

[Claim 5] a claim 4 -- setting -- a conductor -- the electric wave black box characterized by a wall surface constituting propagation space in a cross centering on a propagation shaft in a cross section perpendicular to a propagation shaft

[Claim 6] a claim 4 -- setting -- a conductor -- the electric wave black box characterized by for a wall surface facing across the space which meets the diagonal line of right n square shapes (n is even number) centering on a propagation shaft in a cross section perpendicular to a propagation shaft, and constituting propagation space

[Claim 7] The electromagnetic wave transceiver test method characterized by arranging the antenna which carries out electro magnetic radiation to the end side on the propagation shaft of the propagation space using the electric wave black box of claims 4, 5, or 6, arranging the antenna which receives an electromagnetic wave to an other end side, and examining transmission and reception of an electromagnetic wave.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Explanatory drawing showing typically the shape of a basic form of the cross waveguide used by this invention.

[Drawing 2] Explanatory drawing for analyzing the property of a cross waveguide.

[Drawing 3] Explanatory drawing showing typically the cross section of the rectangular waveguide used as the foundation which analyzes the property of a cross waveguide.

[Drawing 4] For (A), (B) is explanatory drawing showing the cross-section electric-field distribution of the TE mode of a cross waveguide, and explanatory drawing showing the cross-section electric-field distribution of the TM mode.

[Drawing 5] Explanatory drawing showing the state of propagation of the pulse E within a cross waveguide cross section (tx, y).

[Drawing 6] The graph which shows the severe earthquake property of the cross waveguide cross section for which it asked in FDTD analysis.

[Drawing 7] The graph which shows the severe earthquake property of the cross waveguide cross section for which it asked in FDTD analysis.

[Drawing 8] the ratio to Lmax of length l of the sleeve of a cross waveguide -- the graph which shows the relation between r (l/Lmax) and a cut off frequency (resonance frequency)

[Drawing 9] The wave form chart showing the electric-field wave of the output which is the analysis result of a cross waveguide.

[Drawing 10] Explanatory drawing showing the electric-field distribution of the cross waveguide cross section which resonated by 200MHz.

[Drawing 11] the ratio to length L of the vertical angle of a cross waveguide, the product of a cut off frequency fc, and Lmax of length l of a sleeve -- explanatory drawing showing a relation with r (l/Lmax)

[Drawing 12] Front view showing one example of the cross waveguide of this invention.

[Drawing 13] The cross section showing the 1st example of the electric wave black box of this invention.

[Drawing 14] The cross section showing an example of arrangement of the wave absorber used since the 2nd example of the electric wave black box of this invention is constituted.

[Drawing 15] (A) the side elevation showing an example of arrangement of the wave absorber of the tabular for constituting the 3rd example of the electric wave black box of this invention, and (B) -- the front view showing the part

[Drawing 16] The cross section showing the 1st example of the anechoic chamber of this invention.

[Drawing 17] The cross section showing the 2nd example of the anechoic chamber of this invention.

[Description of Notations]

C-- a conductor -- a wall surface, S-- propagation space, and Z-- -- a propagation shaft, 10 -- part I material, 20 -- part II material, and 30 -- -- the part III material, 11 and 21, the 31--V character section, 12, 12, 22, 22 and 32, 32 -- flat part, 13, 23 and 33, 34 -- connection section, and 50 -- -- the connection section, a 60 -- auxiliary member, 71, 72, 73, 74, 80 and

[Translation done.]

* NOTICES *

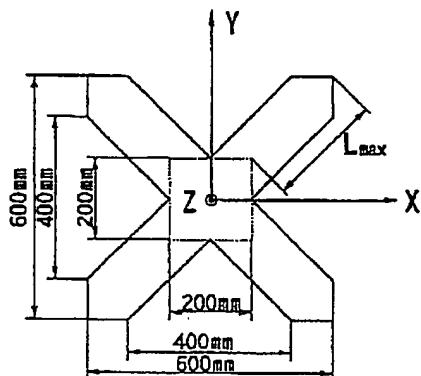
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DRAWINGS

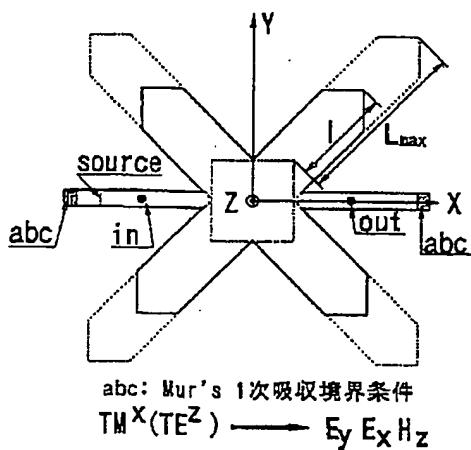
[Drawing 1]

図1



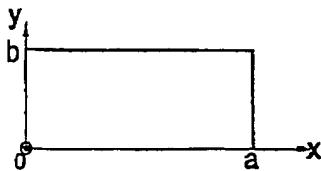
[Drawing 2]

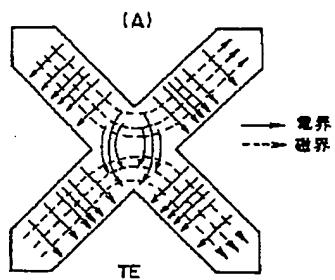
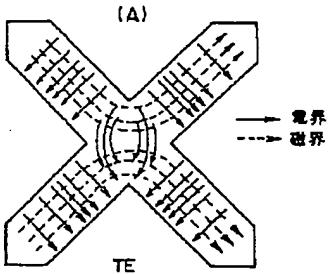
図2



[Drawing 3]

図3



[Drawing 4] 

(B)

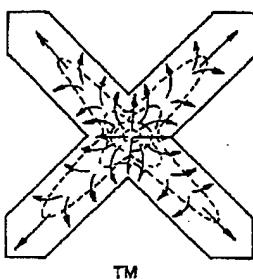
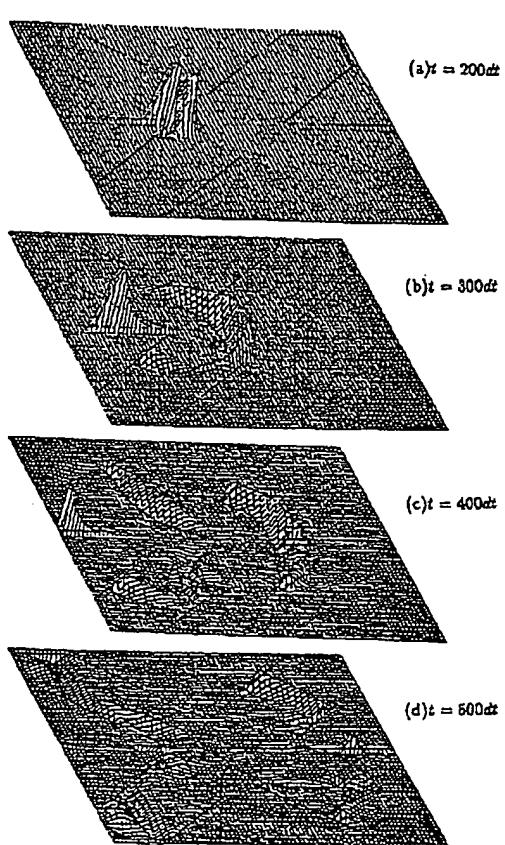
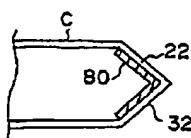
[Drawing 5] 

図5

(a) $t = 200dt$ (b) $t = 300dt$ (c) $t = 400dt$ (d) $t = 500dt$

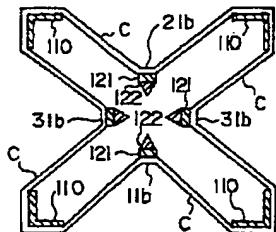
[Drawing 14]

図 14



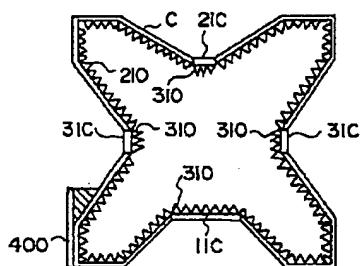
[Drawing 16]

図 16



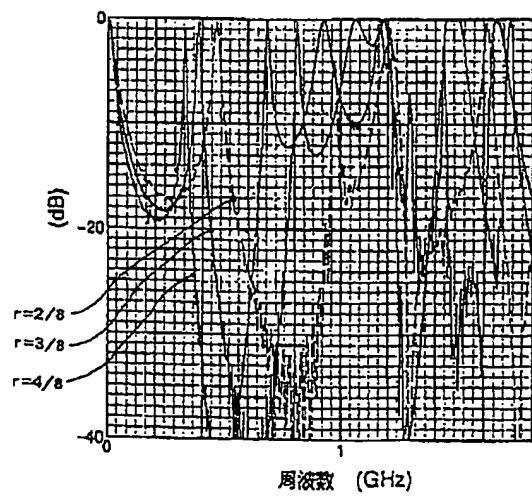
[Drawing 17]

図 17



[Drawing 6]

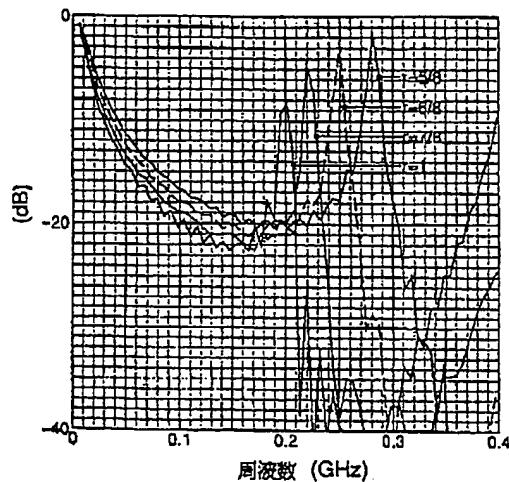
図 6



$r = 2/8, 3/8, 4/8$ の場合

[Drawing 7]

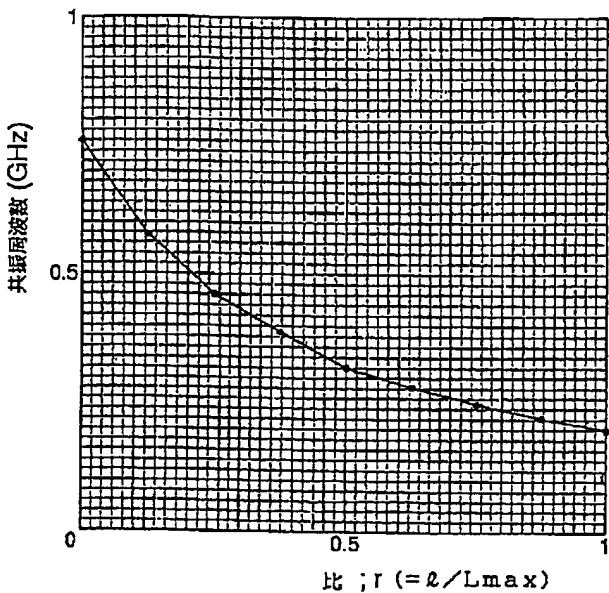
図7



$r = 5/8, 6/8, 7/8, 1$ の場合

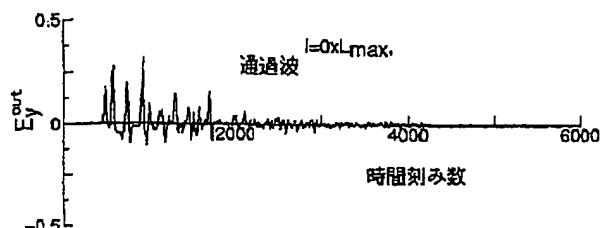
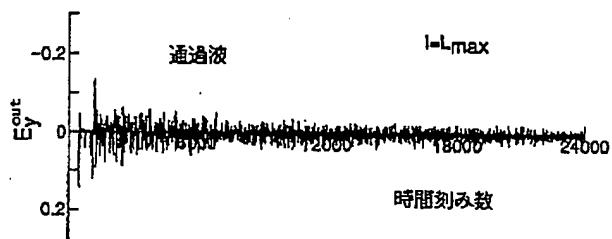
[Drawing 8]

図8

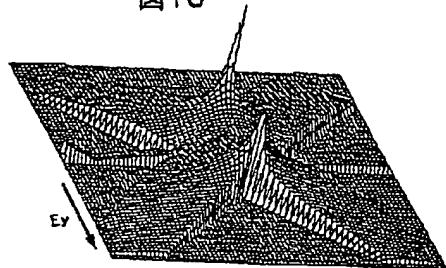
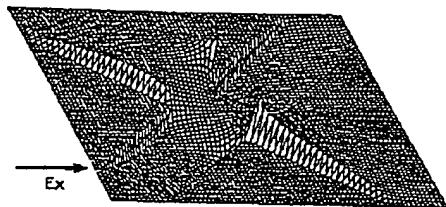
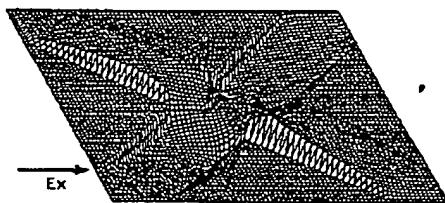


[Drawing 9]

図9

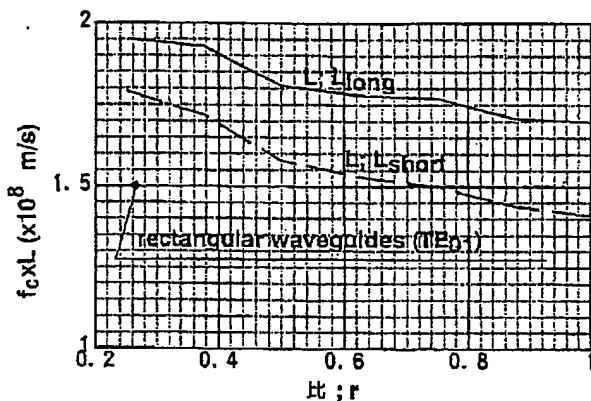
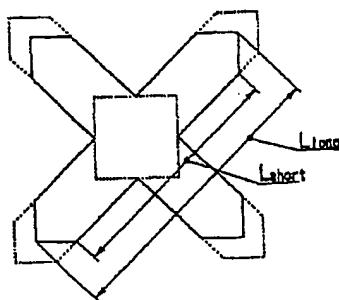
(a) 軸の長さが零の場合 ($l=0$)(b) 軸の長さが $L_{max} = 282.8mm$ の場合 ($l=1$)

[Drawing 10] 図10

(a) E_y (b) E_z (c) E_x (陰線処理無し)

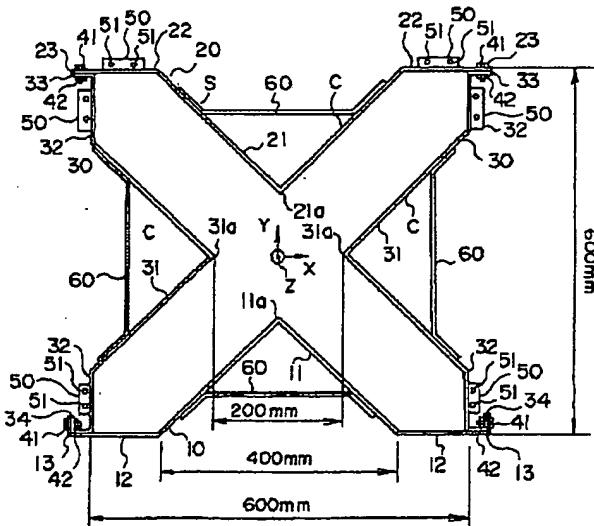
[Drawing 11]

図 11

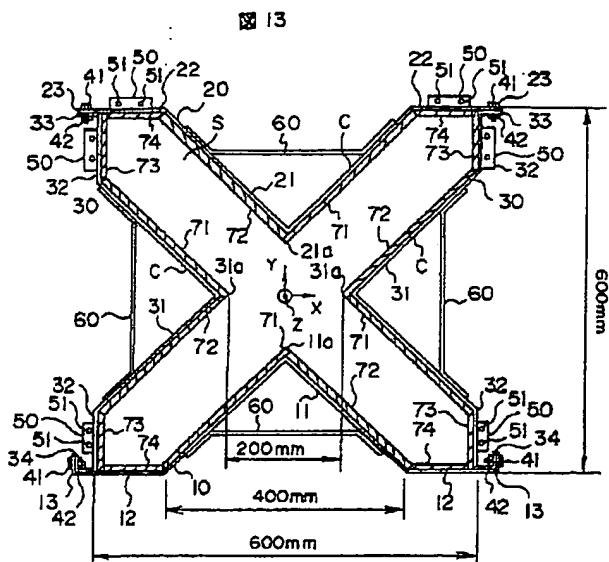
図 17: $f_c \times L$ と ratio;r の関係

[Drawing 12]

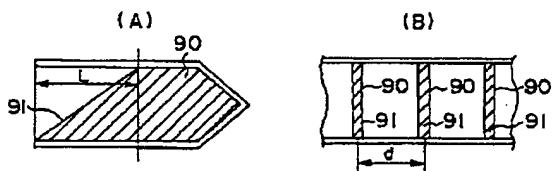
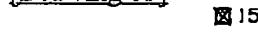
図 12



[Drawing 13]



[Drawing 15]



[Translation done.]